9   automatically, under computer program control, revising the initial computer program

10   to generate a revised computer program by adding object loading instructions to the initial

11   computer program at the first set of the identified program locations, wherein the added

12   object loading instructions, during execution of the revised computer program, load

13   respective ones of the objects from persistent storage of the computer into the main memory

14   when each respective object is accessed and the respective object is not already in the main

15   memory.

16   23.   The method of claim 22, wherein the added object loading instructions are inactive

17   during execution of the revised computer program except when a respective object to be

18   accessed is referenced by a null location indicator.

1   24.   The method of claim 22,

2   the revising further includes:

3   adding dirty object marking instructions to the initial computer program that,

4   during execution of the revised computer program, store object marking data indicating

5   which objects in the main memory contain new and/or updated data; and

6   adding object storing instructions to the initial computer program that, during

7   execution of the revised computer program, store certain respective objects in the main

8   memory into the persistent storage;

9   wherein the certain respective objects stored into the persistent storage by the object

10   storing instructions contain new and/or updated data as indicated by the object marking data.

1   25.   The method of claim 24, wherein the object storing instructions include instructions

2   for replacing main memory object references in the certain respective objects with

3   corresponding persistent storage object identifiers before storing the certain respective objects

4   in the persistent storage.

1   26.   A method of generating object-oriented computer programs for accessing and

2   updating persistently stored objects, wherein the method is performed under program control

3   by a computer, the method comprising:

receiving an initial computer program that includes original instructions for accessing and updating objects stored in a computer's main memory and for committing transactions in

6   which one or more objects may have been updated;

7   scanning the initial computer program to automatically identify object updating

8   instructions and transaction commit instructions and corresponding program locations at

9   which additional instructions are to be added representing a set of identified program

10 locations;

11   automatically, under computer program control, revising the initial computer program

12 to generate a revised computer program by:

13   adding at a first subset of the identified program locations dirty object marking

14 instructions to the initial computer program that, during execution of the revised computer

15 program, store object marking data indicating which objects in the computer's main memory

16 contain new and/or updated data; and

17   adding at a second subset of the identified program locations object storing

18 instructions to the initial computer program that, during execution of the revised computer

19 program, store certain respective objects in the computer's main memory into the persistent

20 storage, wherein the object marking data stored by the dirty object marking instructions is

21 used by the object storing instructions to identify the certain respective objects.

1   27.   The method of claim 26, wherein the object storing instructions include instructions

2   for replacing local object references in the certain respective objects with corresponding

3   persistent storage object identifiers before storing the certain respective objects in the

4   persistent storage, wherein the local object references reference objects in the main memory

5   and the persistent storage object identifiers reference objects in the persistent storage.

1   28.   A method of generating object-oriented computer programs for accessing and

2   updating persistently stored objects, wherein the method is performed under program control

3   by a computer, the method comprising:

4   scanning an initial computer program to automatically identify object accessing

5   instructions and object updating instructions and corresponding program locations at which

6   additional instructions are to be added;

automatically revising the initial computer program to generate a revised computer program by adding supplemental instructions to the initial computer program at the identified

9   program locations, the supplemental instructions including:

10   a first set of additional instructions, added to the initial computer program at a

11   first subset of the identified program locations associated with identified object accessing

12   instructions, wherein the first set of additional instructions, during execution of the revised

13   computer program, perform a first predefined task when each respective object is accessed

14   and the respective object is not already in main memory of the computer; and

15   a second set of additional instructions, added to the initial computer program

16   at a second subset of the identified program locations associated with the identified object

17   updating instructions, wherein the second set of additional instructions, during execution of

18   the revised computer program, perform a second predefined task when each respective object

19   is updated for a first time.

1   29.   The computer implemented method of claim 28, wherein the first predefined task

2   includes loading respective ones of the objects from persistent storage of the computer into

3   the main memory of the computer when each respective object is accessed and the respective

4   object is not already in the main memory.

1   30.   The computer implemented method of claim 29, wherein the second predefined task

2   includes storing object marking data indicating which objects in the main memory contain

3   new and/or updated data.

1   31.   The computer implemented method of claim 29, wherein

2   the scanning includes scanning the initial computer program to automatically identify

3   transaction commit instructions and corresponding program locations at which further

4   additional instructions are to be added to the initial computer program;

5   the revising includes adding at a third subset of the identified program locations

6   object storing instructions to the initial computer program that, during execution of the

7   revised computer program, store certain respective objects in the computer's main memory

8   into the persistent storage, wherein the object marking data stored by the dirty object marking

9   instructions is used by the object storing instructions to identify the certain respective objects.

32.   A computer program product for use in conjunction with a computer having a main

memory and persistent storage, the computer program product comprising a computer

3   readable storage medium and a computer program mechanism embedded therein, the

4   computer program mechanism comprising:

5   a postprocessor procedure for modifying an initial computer program that includes

6   original instructions for accessing and updating objects stored in a computer's main memory;

7   the postprocessor procedure including instructions for:

8   receiving an initial computer program that includes original instructions for accessing

9   objects stored in a computer's main memory;

10   scanning the initial computer program to automatically identify object accessing

11   instructions and corresponding program locations at which additional instructions are to be

12   added representing a first set of identified program locations;

13   automatically, under computer program control, revising the initial computer program

14   to generate a revised computer program by adding object loading instructions to the initial

15   computer program at the first set of the identified program locations, wherein the added

16   object loading instructions, during execution of the revised computer program, load

17   respective ones of the objects from persistent storage of the computer into the main memory

18   when each respective object is accessed and the respective object is not already in the main

19   memory.

1   33.   The computer program product of claim 32, wherein the added object loading

2   instructions are inactive during execution of the revised computer program except when a

3   respective object to be accessed is referenced by a null location indicator.

1   34.   The computer program product of claim 32, wherein

2   the revising instructions further include instructions for:

3   adding dirty object marking instructions to the initial computer program that,

4   during execution of the revised computer program, store object marking data indicating

5   which objects in the main memory contain new and/or updated data; and

6   , adding object storing instructions to the initial computer program that, during

7   execution of the revised computer program, store certain respective objects in the main

8   memory into the persistent storage;

9   wherein the certain respective objects stored into the persistent storage by the object

10   storing instructions contain new and/or updated data as indicated by the object marking data.

1   35.   The computer program product of claim 34, wherein the object storing instructions

2   include instructions for replacing main memory object references in the certain respective

3   objects with corresponding persistent storage object identifiers before storing the certain

4   respective objects in the persistent storage.

1   36.   A computer program product for use in conjunction with a computer having a main

2   memory and persistent storage, the computer program product comprising a computer

3   readable storage medium and a computer program mechanism embedded therein, the

4   computer program mechanism comprising:

5   a postprocessor procedure for modifying an initial computer program that includes

6   original instructions for accessing and updating objects stored in a computer's main memory;
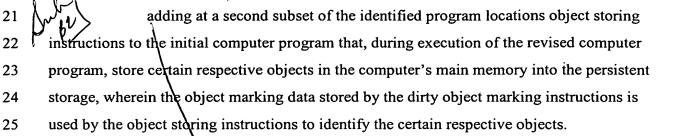
7   the postprocessor procedure including instructions for:

8   receiving an initial computer program that includes original instructions for accessing

9   and updating objects stored in a computer's main memory and for committing transactions in

10   which one or more objects may have been updated;

11   scanning the initial computer program to automatically identify object updating

12   instructions and transaction commit instructions and corresponding program locations at

13   which additional instructions are to be added representing a set of identified program

14   locations;

15   automatically, under computer program control, revising the initial computer program

16   to generate a revised computer program by:

17   adding at a first subset of the identified program locations dirty object marking

18   instructions to the initial computer program that, during execution of the revised computer

19   program, store object marking data indicating which objects in the computer's main memory

20   contain new and/or updated data; and

21   adding at a second subset of the identified program locations object storing

22   instructions to the initial computer program that, during execution of the revised computer

23   program, store certain respective objects in the computer's main memory into the persistent

24   storage, wherein the object marking data stored by the dirty object marking instructions is

25   used by the object storing instructions to identify the certain respective objects.

1   37.   The computer program product of claim 36, wherein the object storing instructions

2   include instructions for replacing local object references in the certain respective objects with

3   corresponding persistent storage object identifiers before storing the certain respective objects

4   in the persistent storage, wherein the local object references reference objects in the main

5   memory and the persistent storage object identifiers reference objects in the persistent

6   storage.

1   38.   A computer program product for use in conjunction with a computer having a main

2   memory and persistent storage, the computer program product comprising a computer

3   readable storage medium and a computer program mechanism embedded therein, the

4   computer program mechanism comprising:

5   a postprocessor procedure for modifying an initial computer program that includes

6   original instructions for accessing and updating objects stored in a computer's main memory;

7   the postprocessor procedure including instructions for:

8   scanning an initial computer program to automatically identify object accessing

9   instructions and object updating instructions and corresponding program locations at which

10   additional instructions are to be added;

11   automatically revising the initial computer program to generate a revised computer

12   program by adding supplemental instructions to the initial computer program at the identified

13   program locations, the supplemental instructions including:

14   a first set of additional instructions, added to the initial computer program at a

15   first subset of the identified program locations associated with identified object accessing

16   instructions, wherein the first set of additional instructions, during execution of the revised

17   computer program, perform a first predefined task when each respective object is accessed

18   and the respective object is not already in main memory of the computer; and

19   a second set of additional instructions, added to the initial computer program

20   at a second subset of the identified program locations associated with the identified object

21   updating instructions, wherein the second set of additional instructions, during execution of

22   the revised computer program, perform a second predefined task when each respective object

23   is updated for a first time.

1   39.   The computer program product of claim 38, wherein the first predefined task includes

2   loading respective ones of the objects from persistent storage of the computer into the main

3   memory of the computer when each respective object is accessed and the respective object is

4   not already in the main memory.

1   40.   The computer program product of claim 39, wherein the second predefined task

2   includes storing object marking data indicating which objects in the main memory contain

3   new and/or updated data.

1   41.   The computer program product of claim 39, wherein

2   the scanning instructions include instructions for scanning the initial computer

3   program to automatically identify transaction commit instructions and corresponding

4   program locations at which further additional instructions are to be added to the initial

5   computer program;

6   the revising instructions include instructions for adding at a third subset of the

7   identified program locations object storing instructions to the initial computer program that,

8   during execution of the revised computer program, store certain respective objects in the

9   computer's main memory into the persistent storage, wherein the object marking data stored

10   by the dirty object marking instructions is used by the object storing instructions to identify

11   the certain respective objects.

1   42.   A computer system, comprising:

2   a central processing unit;

3   memory, including a main memory for temporarily storing objects and persistent

4   storage for durably storing objects;

5   the memory further storing an initial computer program and a postprocessor

6   procedure, executable by the central processing unit, for modifying an initial computer

7   program so as to generate the revised computer program, the initial computer programing

8   including original instructions for accessing objects stored in the main memory;

9   the postprocessor procedure including instructions for:

10   receiving an initial computer program that includes original instructions for accessing

11   objects stored in a computer's main memory;

12   scanning the initial computer program to automatically identify object accessing

13   instructions and corresponding program locations at which additional instructions are to be

14   added representing a first set of identified program locations;

15   automatically, under computer program control, revising the initial computer program

16   to generate a revised computer program by adding object loading instructions to the initial

17   computer program at the first set of the identified program locations, wherein the added

18   object loading instructions, during execution of the revised computer program, load

19   respective ones of the objects from persistent storage of the computer into the main memory

20   when each respective object is accessed and the respective object is not already in the main

21   memory.

1   43.   The computer system of claim 42, wherein the added object loading instructions are

2   inactive during execution of the revised computer program except when a respective object to

3   be accessed is referenced by a null location indicator.

1   44.   The computer system of claim 42, wherein

2   the revising instructions further include instructions for:

3   adding dirty object marking instructions to the initial computer program that,

4   during execution of the revised computer program, store object marking data indicating

5   which objects in the main memory contain new and/or updated data; and

6   adding object storing instructions to the initial computer program that, during

7   execution of the revised computer program, store certain respective objects in the main

8   memory into the persistent storage;

9   wherein the certain respective objects stored into the persistent storage by the object

10   storing instructions contain new and/or updated data as indicated by the object marking data.

45. The computer system of claim 44, wherein the object storing instructions include instructions for replacing main memory object references in the certain respective objects with corresponding persistent storage object identifiers before storing the certain respective objects in the persistent storage.

46. A computer system, comprising:

a central processing unit;

memory, including a main memory for temporarily storing objects and persistent storage for durably storing objects;

the memory further storing an initial computer program and a postprocessor procedure, executable by the central processing unit, for modifying an initial computer program so as to generate the revised computer program, the initial computer programing including original instructions for accessing objects stored in the main memory;

the postprocessor procedure including instructions for:

receiving an initial computer program that includes original instructions for accessing and updating objects stored in a computer's main memory and for committing transactions in which one or more objects may have been updated;

scanning the initial computer program to automatically identify object updating instructions and transaction commit instructions and corresponding program locations at which additional instructions are to be added representing a set of identified program locations;

automatically, under computer program control, revising the initial computer program to generate a revised computer program by:

adding at a first subset of the identified program locations dirty object marking instructions to the initial computer program that, during execution of the revised computer program, store object marking data indicating which objects in the computer's main memory contain new and/or updated data; and

adding at a second subset of the identified program locations object storing instructions to the initial computer program that, during execution of the revised computer program, store certain respective objects in the computer's main memory into the persistent

storage, wherein the object marking data stored by the dirty object marking instructions is used by the object storing instructions to identify the certain respective objects.

1   47.   The computer system of claim 46, wherein the object storing instructions include
2   instructions for replacing local object references in the certain respective objects with
3   corresponding persistent storage object identifiers before storing the certain respective objects
4   in the persistent storage, wherein the local object references reference objects in the main
5   memory and the persistent storage object identifiers reference objects in the persistent
6   storage.

1   48.   A computer system, comprising:
2   a central processing unit;
3   memory, including a main memory for temporarily storing objects and persistent
4   storage for durably storing objects;
5   the memory further storing an initial computer program and a postprocessor
6   procedure, executable by the central processing unit, for modifying an initial computer
7   program so as to generate the revised computer program, the initial computer programing
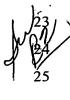8   including original instructions for accessing objects stored in the main memory;
9   the postprocessor procedure including instructions for:
10   scanning an initial computer program to automatically identify object accessing
11 instructions and object updating instructions and corresponding program locations at which
12 additional instructions are to be added;
13   automatically revising the initial computer program to generate a revised computer
14 program by adding supplemental instructions to the initial computer program at the identified
15 program locations, the supplemental instructions including:
16   a first set of additional instructions, added to the initial computer program at a
17 first subset of the identified program locations associated with identified object accessing
18 instructions, wherein the first set of additional instructions, during execution of the revised
19 computer program, perform a first predefined task when each respective object is accessed
20 and the respective object is not already in main memory of the computer; and
21   a second set of additional instructions, added to the initial computer program
22 at a second subset of the identified program locations associated with the identified object

23 updating instructions, wherein the second set of additional instructions, during execution of

24 the revised computer program, perform a second predefined task when each respective object

25 is updated for a first time.

1 49. The computer system of claim 48, wherein the first predefined task includes loading

2 respective ones of the objects from persistent storage of the computer into the main memory

3 of the computer when each respective object is accessed and the respective object is not

4 already in the main memory.

1 50. The computer system of claim 49, wherein the second predefined task includes storing

2 object marking data indicating which objects in the main memory contain new and/or

3 updated data.

1 51. The computer system of claim 49, wherein

2 the scanning instructions include instructions for scanning the initial computer

3 program to automatically identify transaction commit instructions and corresponding

4 program locations at which further additional instructions are to be added to the initial

5 computer program;

6 the revising instructions include instructions for adding at a third subset of the

7 identified program locations object storing instructions to the initial computer program that,

8 during execution of the revised computer program, store certain respective objects in the

9 computer's main memory into the persistent storage, wherein the object marking data stored

10 by the dirty object marking instructions is used by the object storing instructions to identify

11 the certain respective objects.